[0040] The suspicion mechanism can be used in conjunction with the decoder to develop an effective data recovery technique. All data including and beyond the suspicious macroblock can be concealed while data prior to the suspicious macroblock can be retained within an erroneous slice. Referring to **FIG. 6**, a suspicious macroblock **306** is detected in slice **300**. The macroblocks between the suspicious macroblock **306** and the previous resynchronization marker **302** may be assume to be correct and is retained. If a syntax error **308** is encountered within the remainder of the slice **300** before the next resynchronization marker **304**, the data between the suspicious block **306** and the resynchronization marker **304** is discarded as being erroneous. If a syntax error is not detected in the remainder of the block, the data may be retained, discarded or subject to further checks. In this manner, the suspicion mechanism may be used as a supportive check. Alternatively, the suspicion mechanism can be used as a definitive check in which if the macroblock is labeled suspicious, an error is flagged and the data discarded immediately.

[0041] This invention requires the computation of the SADs along the boundaries of the macroblock and averaging to obtain the average SAD and in computing the adaptive threshold. These steps can be implemented efficiently. Furthermore, the data is checked only once allowing for the possible reuse of some of the SAD results if all boundaries all tested.

[0042] A flow chart depicting the preferred embodiment of the method is shown in **FIG. 7**. The method begins at start block **700**. The current data is retrieved at block **702** and a check is made at decision block **704** to determine if the data corresponds to the start of a new slice. If the data does correspond to the start of a new slice, as depicted by the positive branch from decision block **704**, a further check is made at decision block **706** to determine if the data corresponds to the start of a new frame. If not, as depicted by the negative branch from decision block **706**, the flow returns to block **702** to get the next data. If it is the start of a new frame, as depicted by the positive branch from decision block **706**, the adaptive thresholds are recalculated at block **708** according to the data in previous frames. If the current frame is the first in a sequence of frames, the thresholds are set to predetermined default values. Flow then returns to block **702** where the next data is retrieved. If the data does not indicate the start of a new slice, as depicted by the negative branch from decision block **704**, the data is macroblock data, and is decoded at block **710**. At decision block **712**, a check is made to determine if the data contained syntactical errors (which may have prevented decoding). If syntactical errors were found, as depicted by the positive branch from decision block **712**, error concealment or recovery is applied at block **722**. The error recovery is applied to all macroblocks between the first suspicious block in the current slice and the end of the current slice, since macroblocks within the current slice may have been inter-coded with reference to the corrupted macroblock. The start of the next slice is detected at block **724**, and flow continues to block **702** to determine if the next slice is the first in a new frame. If no syntax errors are detected, as depicted by the negative branch from decision block **712**, the average sum of absolute differences (ASADs) for one or more of the luminance and chrominance channels are calculated at block **714**. At decision block **716**, the one or more ASAD values are compared with the corresponding adapted thresholds. If any of the ASAD values is greater than the corresponding threshold, as depicted by the positive branch from decision block **716**, the macroblock is marked as being suspicious at block **718**. If none of the values is greater than the corresponding threshold, as depicted by the negative branch from decision block **716**, further checks may be performed of the macroblock can be stored at block **720**. Flow then continues to block **702**, where the next data are retrieved.

[0043] The disclosed invention offers benefits in a variety of applications. It is an efficient and adaptive mechanism that allows for errors to be detected within coded video sequences, allowing for good data to be retained. Moreover, the adaptation of the detection thresholds allows detection and recovery to operate with a reduced dependency on the content of the video.

[0044] The error detection method described above provides added error resilience for standards based video decoders by recovering data that otherwise would have been lost due to bit errors. This is especially important when transmitting video over wireless channels and the Internet where errors can be severe.

[0045] The disclosed method improves decoder performance in a variety of applications, including one-way and two-way video communications, surveillance applications, and video streaming. Other applications will be apparent to those of ordinary skill in the art.

[0046] While the invention has been described in conjunction with specific embodiments, it is evident that many alternatives, modifications, permutations and variations will become apparent to those of ordinary skill in the art in light of the foregoing description. Accordingly, it is intended that the present invention embrace all such alternatives, modifications and variations as fall within the scope of the appended claims.

What is claimed is:

1. A method for detecting errors in a digital video signal comprising a sequence of image frames, each image frame comprising a sequence of image slices, each image slice comprising a sequence of macroblocks and each macroblock comprising a plurality of pixels, said method comprising:

detecting the start of an image frame;

updating a threshold level according to data received in at least one previous image frame;

detecting the start of an image slice; and

for each macroblock within the image slice:

calculating one or more error metrics between pixel values of the plurality of pixels along one or more edges of the macroblock and pixel values along

corresponding bordering edges of adjoining macroblocks of the image slice; and

labeling as suspicious any macroblock of the image slice for which the one or more error metrics is greater than the threshold level.

2. A method as in claim 1, wherein the pixel values are one or more channel components, wherein an error metric of the one or more error metrics between the pixel values is calculated for one or more of the one or more channel components.

3. A method as in claim 2, wherein the threshold level is updated for one or more of the one or more channel components.

4. A method as in claim 3, wherein a macroblock of the sequence of macroblocks is labeled as suspicious if the one or more error metrics between pixel values for any of the one or more channel components is greater than the threshold level for one or more corresponding channel components.

5. A method as in claim 1, wherein the threshold level is a weighted average of the one or more error metrics in pixel values along macroblock boundaries in at least one previous image frame.

6. A method as in claim 1, further comprising:

if a macroblock of the image slice is labeled as suspicious, regenerating the macroblock and all subsequent macroblocks in the of the sequence of macroblocks of an image slice in accordance with a concealment strategy.

7. A method as in claim 1, further comprising:

detecting syntax errors in the macroblock; and

if a syntax error is detected, further comprising:

retaining those macro blocks within the image slice received prior to all macroblocks of the image slice labeled as suspicious; and

regenerating all remaining macroblocks within the image slice in accordance with a concealment strategy.

8. A method as in claim 1, wherein an error metric of the one or more error metrics is a sum of absolute differences.

9. A system for decoding a digital video signal comprising a sequence of image frames, each image frame comprising a sequence of image slices, each image slice comprising a sequence of macroblocks and each macroblock comprising a plurality of pixels, said system comprising:

an input for receiving said digital video signal;

an image frame store for storing a previous image frame;

a macroblock decoder coupled to the input that receives said digital video signal and to said image frame store; and

an error detector coupled to the macroblock decoder,

wherein said error detector is operable to calculate one or more error metrics between pixel values of the plurality of pixels on at least part of a boundary between a current macroblock and one or more adjoining macroblocks and to label the current macroblock as suspicious if the one or more error metrics is greater than a threshold level which is a weighted average error metric from one or more previous image frames.

10. A system as in claim 9, wherein an error metric of the one or more error metrics is a sum of absolute differences.

11. A system as in claim 9, wherein said macroblock decoder comprises:

a demultiplexer coupled to the input that receives said digital video signal and configured to output compressed, quantized coefficient data and compressed motion vector data;

an inverse variable-length coder coupled to said demultiplexer and configured to output quantized coefficient data and motion vector data;

an inverse quantizer coupled to said inverse variable-length coder and configured to receive said quantized coefficient data and generate coefficient data;

an inverse discrete cosine transformer coupled to the inverse quantizer and configured to receive said coefficient data and generate a differential macroblock;

a motion compensator coupled to said inverse variable-length coder and configured to receive said motion vector data and a previous image frame and generate a previous motion compensated macroblock; and

a signal combiner configured to combine said previous motion compensated macroblock and said differential macroblock to produce a decoded macroblock.

12. A system as in claim 9, further comprising an error concealment element coupled to said error detector and said image frame store.

13. A system as in claim 12, wherein said error concealment element operates to regenerate any subsequent macroblocks in an image slice if the current macroblock is labeled as suspicious.

14. A system as in claim 12, further comprising:

a syntax error detector, which is operable to detect syntax errors in the digital video signal, coupled to the error detector.

15. A system as in claim 14, wherein said error concealment element operates to regenerate any macroblocks in an image slice of the sequence of image slices that follows a macroblock labeled suspicious if a syntax error is detected by said syntax error detector.

16. A system as in claim 9, wherein the pixel values are one or more channel components, wherein the one or more error metrics between the pixel values is calculated for one or more of the one or more channel components.

17. A system as in claim 16, wherein a macroblock is labeled as suspicious if any of the one or more error metrics between the pixel values is greater than the threshold level in one or more corresponding components of the one or more channel components from one or more previous image frames.

18. A device for detecting errors in a digital video signal comprising a sequence of image frames, each image frame comprising a sequence of image slices and each image slice comprising a sequence of macroblocks and each macroblock comprising a plurality of pixels, wherein the device is directed by a computer program that is embedded in at least one of:

(a) a memory;

(b) an application specific integrated circuit;

(c) a digital signal processor; and

(d) a field-programmable gate array.

wherein the computer program comprises:

detecting the start of an image frame;

updating a threshold level according to data received in at least one previous image frame;

detecting the start of an image slice; and,

for each macroblock within the image slice:

calculating one or more error metrics between pixel values along one or more edges of the macroblock and pixel values along corresponding bordering edges of adjoining macroblocks;

labeling as suspicious any macroblock for which the one or more error metrics is greater than the threshold level.

19. A device as in claim 18, wherein an error metric of the one or more error metrics is a sum of absolute differences.

20. A device as in claim 18, wherein the pixel values are one or more channel components and wherein an error metric of the one or more error metrics between the pixel values is calculated for one or more of the one or more channel components.

21. A device as in claim 22, wherein the threshold level is updated for one or more of the one or more channel components.

22. A device as in claim 21, wherein a macroblock is labeled as suspicious if the one or more error metrics between pixel values for one or more of the one or more channel components is greater than the threshold level.

23. A device as in claim 18, wherein the threshold level is a weighted average of the one or more error metrics between pixel values along macroblock boundaries in at least one previous image frame.

24. A device as in claim 18, further comprising:

regenerating all remaining macroblocks in accordance with a concealment strategy if a macroblock is labeled as suspicious.

25. A device as in claim 18, further comprising:

detecting syntax errors in the macroblock; and

if a syntax error is detected:

retaining those macroblocks within the image slice received prior to all macroblocks labeled as suspicious; and

regenerating all remaining macroblocks within the image slice in accordance with a concealment strategy.

26. A computer readable medium containing instructions which, when executed on a computer, carry out a process of detecting errors in a digital video signal, said process comprising:

detecting the start of an image frame;

updating a threshold level according to data received in at least one previous image frame;

detecting the start of an image slice; and,

for each macroblock within the image slice:

calculating an error metric between pixel values along one or more edges of the macroblock and pixel values along corresponding bordering edges of adjoining macroblocks; and

labeling as suspicious any macroblock for which the error metric is greater than the threshold level.

27. A computer readable medium as in claim 26, wherein the values of the pixels are one or more channel components, wherein an error metric of the one or more error metrics between the pixel values is calculated for one or more of the one or more channel components.

28. A computer readable medium as in claim 27, wherein the threshold level is updated for one or more of the one or more channel components.

29. A computer readable medium as in claim 27, wherein a macroblock is labeled as suspicious if the one or more error metrics between pixel values for one or more of the first, second, and third channel components is greater than the threshold level.

30. A computer readable medium as in claim 26, wherein the threshold level is a weighted average of the error metric between pixel values along macroblock boundaries in at least one previous image frame.

31. A computer readable medium as in claim 26, wherein said process further comprises:

regenerating all remaining macroblocks are regenerated according to a concealment strategy if a macroblock is labeled as suspicious.

32. A computer readable medium as in claim 26, wherein said process further comprises:

detecting syntax errors in the macroblock; and, if a syntax error is detected:

retaining those macroblocks within the image slice received prior to all macroblocks labeled as suspicious; and

regenerating all remaining macroblocks within the image slice according to a concealment strategy.

33. A computer readable medium as in claim 26, wherein an error metric of the one or more error metrics is a sum of absolute differences.

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